Scaling Dependence on the Fuid Viscosity Ratio in the Selective Withdrawal Transition

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Abstract: Understanding and controlling how a liquid interface changes its topology from being singly connected to being multiply connected (as is the case with a drop dripping from a faucet) or from being bounded to being unbounded in a particular direction (as is the case in the selective withdrawal problem) is crucial for the control of many manufacturing processes including the creation of emulsions and mono-dispersed sprays. In this talk I will discuss two beautiful phenomena which explore and shed light on these issues. First I will discuss experiments on the two fluid drop snap-off problem, where fluid is dripped through an outside liquid medium. In my brief overview of this problem I will discuss how scaling and similarity profiles can be used to classify the different shapes that fluid interfaces adopt at snap-off. I will then go on to discuss the extension of these techniques to the selective withdrawal experiment. Here, fluid is withdrawn through a tube with its tip suspended a distance S above a two-fluid interface. At sufficiently low withdrawal rates, Q, the interface forms a steady state hump and only the upper fluid is withdrawn. When Q is increased (or S decreased), the interface undergoes a transition so that the lower fluid is entrained with the upper one, forming a thin steady-state spout. Near this transition the hump curvature becomes very large and displays power-law scaling behavior. This scaling allows for steady-state hump profiles at different flow rates and tube heights to be scaled onto a single similarity profile. Contrary to what might be expected, the scaling behavior is independent of the viscosity ratio. Finally, I will conclude with a description of a technological application that we have invented which takes advantage of the selective withdrawal geometry to apply thin coats onto micron sized particles.